#1

Alnor

DEW POINTER
INSTRUCTIONS

ILLINOIS TESTING LABORATORIES, INC.
CHICAGO 10, ILLINOIS

IMPORTANT

DO NOT FAIL TO READ
MAINTENANCE INSTRUCTIONS
ON PAGE 5

INSTRUCTIONS

For "ALNOR" TYPE 7000 DEW POINTERS

INDEX

	Page Numbers
Introduction	1
Operation	
Principle	6
Connections	1
Adjustment	1
Operation	1
As a Go-No-Go Gage	11
Maintenance	5
Calculator	4
Q Value	
Definition	6
Common Gases	2
Heat Treating Mixtures	
Types	3
Trade Name	4
Computation	8
K to Q Conversion ..... After Page	8
Required Accuracy	10
Vapor Density	10
Vapor Pressure	10
Elevated Pressure Dew Point Measuring	11
Psychrometric Charts	11

FIGURES

Number	Title	After Page Number.
1	Schematic Diagram	1
2	Alnor Dew Pointer	1
3	K to Q Conversion Curve	8
4	Q Value of Gas Mixtures	9
5	Effect of Q Value on Dew Point Indicator	On 10
6	Vapor Pressure & Vapor Density Curve	
7	(-100 to 30°F)	10
	(-30 to 110°F)	10
8	Dew Point Conversion Chart (for elevated pressures)	11
9	Psychrometric Chart (1 to 14% R. H.)	11
10	Psychrometric Chart (Standard)	11

TABLES

Number	Title	Page Numbers
1	Q Values of Common Gases	2
2	Q Values for Gas Mixtures used in heat treating (by types)	3
3	(by trade names)	4
4	Gas Constants	9
5	Temperature Conversion	12

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INSTRUCTIONS FOR "ALNOR" TYPE 7000 DEW POINTERS

Introduction:

"Alnor" type 7000 Dew Pointers can be used to determine the dew point temperature of air and other non-corrosive gases. It is particularly effective in determining the dew points of comparatively dry gases, a dew point region where most other methods became difficult or impossible to use.

The instrument is available in four nominal dew point ranges as follows:

TYPE	NOMINAL DEW POINT RANGE
7000H	Room Temp. to -20°F.
7000U	Room Temp. to -80°F.
7000L	0°F. to -80°F.
7300	Room Temp to -80°F.

The actual range of each instrument is dependent on the temperature of the Dew Pointer and the gas being tested in addition to the range of the pressure ratio gauge.

The convenience, portability, accuracy, reproducability (several different operators can easily get the same results) and freedom from the use of an external coolant, make the instrument highly desireable.

Observe the following instructions carefully. It will be helpful if the "Principle of Operation" be read carefully since an understanding of the principle will aid materially in the intelligent use of the instrument.

Connections

On A. C. models connect the Dew Pointer to a convenient 50 or 60 cycle A. C. source of the voltage indicated on the instrument name plate, by means of the cable provided.

Connect the source of gas to the inlet (bottom center) of the meter. Copper connecting tubing is most desireable (sweat the copper tubing to the fitting supplied), although a dense neoprene tubing may be used for dew points above -20°F. Ordinary rubber tubing may cause large errors. **All Connections Must Be Tight.**

If the source of gas is at a pressure appreciably above atmospheric pressure a shut off valve should be provided in the inlet line.

The outlet of the Dew Pointer (rear) may be connected to a suitable waste line if desired.

Adjustments

Before operating the Dew Pointer, a Unity Adjustment must be made on the Pressure Ratio Gauge as follows:

1. Place operating valve in out position.
2. Open Purging Valve to be sure there is no pressure in the instrument.
3. Depress the Gauge Valve and turn the Unity Adjuster until the bottom of the meniscus is in line with thel mark.
4. Release the Gauge Valve.

Close the purging valve and pump up the instrument until the pressure ratio gauge reads about .5. Open the purging valve. If the meniscus does not return to the 1 mark after a few moments, repeat the unity adjustment as above. It sometimes happens that after a period of prolonged idleness the flexible diaphragm in the oil reservoir takes a set, but the above operation will correct the condition.

If the source of gas is above atmospheric pressure be sure to shut off the source of pressure before making the unity adjustment.

WARNING: Never depress the gauge valve unless the operating valve is out and the purging valve open, and the supply valve closed.

The unity adjustment should be checked frequently - particularly if the instrument temperature or barometer pressure is fluctuating.

Operation

Open the purging valve. Pull out the operating valve. Turn the switch to "ON". On combination A. C. and Battery instruments place switch in the "A. C." or "B" position according to the power source that is to be used.

Pump the gas to be tested thru the instrument to flush out all the old gas in the Dew Pointer (at least 10 to 15 strokes of the pump). When very low dew points are to be tested more thorough purging is required. The Dew Pointer will give the correct dew point of the sample in the instrument. Be sure to flow enough gas thru so that the gas in the instrument is the gas you want to test.

When the gas is generated under pressure, permit this pressure to force the gas

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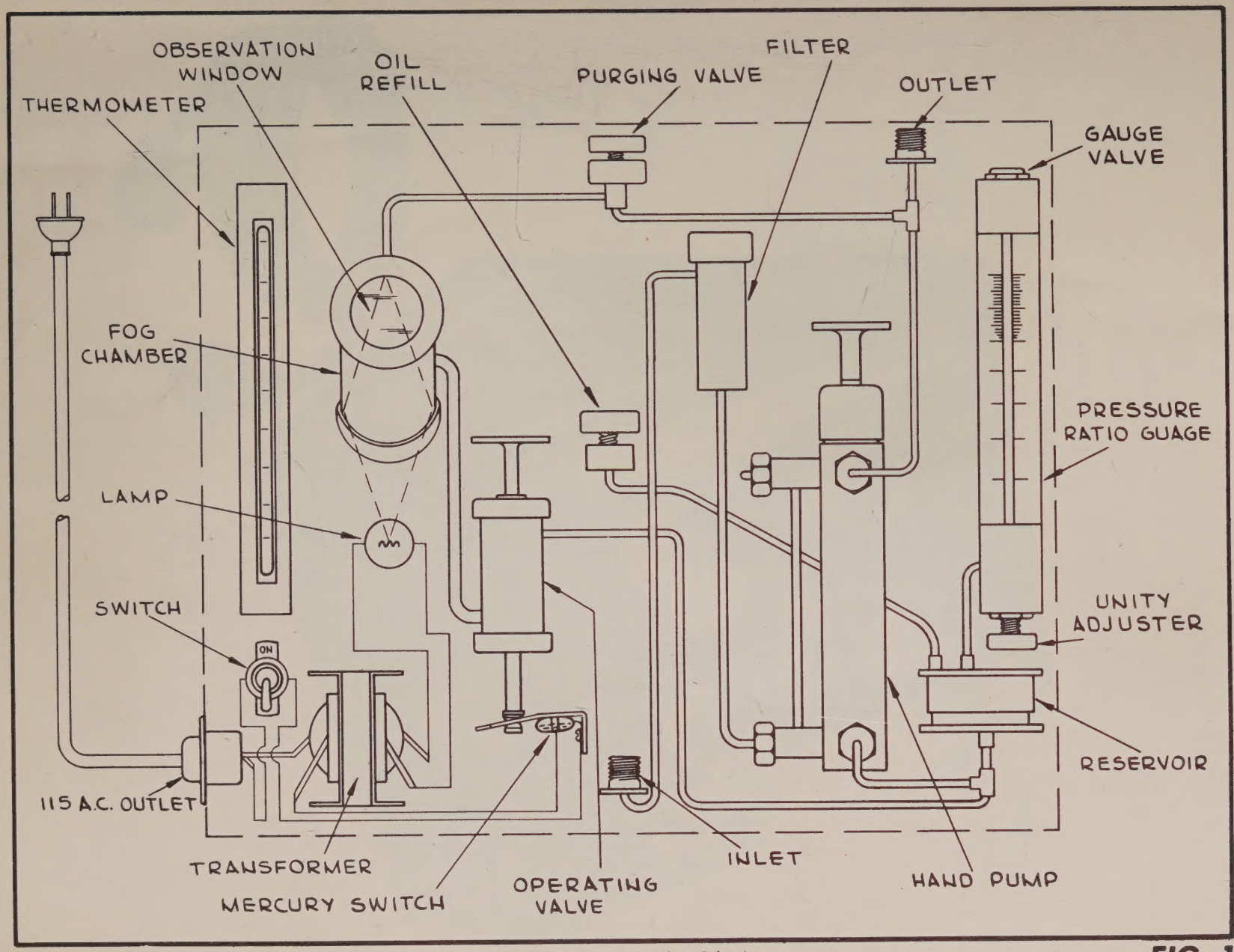
When the gas is generated under pressure, permit this pressure to force the gas



SCHEMATIC DIAGRAM

FIG. 1

PURGING VALVE
FILTER
OIL REFILL
GAUGE VALVE
OBSERVATION WINDOW
PRESSURE RATIO GAUGE
THERMOMETER
UNITY ADJUSTER
SWITCH
HAND PUMP
INLET
OPERATING VALVE

FIG. 2

thru the instrument to perform the purging operation, and minimize the pumping.

Close the purging valve. Pump a sample of gas in the instrument. Look into the observation window and press down on the operating valve.

Depressing the operating valve actually performs three operations in the following sequence.

1. Closes line from the inlet and pressure ratio gauge.
2. Turns on the light.
3. Rapidly opens the line from fog chamber to the atmosphere.

If a fog (cone of sunbeams) appears, it indicates the gas was cooled below the dew point and subsequent trials should be made at lower pressures (numerically higher pressure ratios). Make similar trials at each higher major division on the pressure ratio gauge until one reading is obtained where no fog appears. Then "Close In" on the end point, i.e. maximum pressure ratio that will produce a fog.

The object of the operation of the Dew Pointer is to determine the pressure ratio that will just produce a fog. This is called the "End Point".

If on the first trial no fog appears, it indicates that the gas was not cooled down to the dew point. It is apparent, therefore, that a lower pressure ratio (higher pressure) is required to produce sufficient cooling to reach the dew point. Subsequent trials should, therefore, be made at each lower (higher pressure) major division on the Pressure Ratio Gauge until one trial is obtained in which a fog appears. Having located one point where there is a fog and one where there is no fog, "close in" on the end point. It is easily possible to get the difference between the appearance and non-appearance of the fog to be only .01 apart, as read on the pressure ratio gauge.

After any trial in which a fog appears, it is advisable to take several strokes on the pump to purge the fog chamber of any droplets of moisture that fail to re-evaporate promptly.

When making the last trials near end point, permit 10 to 15 seconds to lapse after pumping the sample into the instrument before pushing down the operating valve to permit the sample to come to the temperature of the fog chamber.

The experienced operator will find he can determine the end point after a few trials since the density of the fog on any given trial is a valuable clue to how far he is from the end point.

If the approximate value of the dew point is known, the reverse operation of the Dew Point Calculator will indicate the approximate Pressure Ratio which should be used for the initial trial. This will further reduce the number of trials required to achieve the end point.

After determining the end point, take the mean between the minimum pressure ratio that fails to produce a fog and the maximum pressure ratio that produces a fog. Use this value with the initial temperature as read on the thermometer and the Q value for the gas being tested to compute the dew point with the "Alnor" Dew Point Calculator.

Q Values

The Q value of a gas is a natural constant of the gas. It is representative of the cooling power of the gas.

The Q value of the gas being tested must be known to arrive at the dew point of the gas. Values of common gases are given below.

TABLE 1

		Q
Air		.2855
Carbon Dioxide	CO_2	.225
Carbon Monoxide	CO	.2855
Hydrogen	H_2	.2855
Methane	CH_4	.240
Nitrogen	N_2	.2855
Oxygen	O_2	.2855
Other Gases	Refer to chemical Handbooks	
Gas Mixtures	Refer to Tables 2 and 3, and the Appendix.	

TABLE 2

Q VALUES FOR COMMON GAS MIXTURES USED IN CONTROLLED ATMOSPHERE HEAT TREATING

Type 1 EXOTHERMIC BASE

Prepared by combustion of gas and air followed by dehydration

Type 1a LEAN MIXTURE: (Air-Gas Ratio 9:1) Q .278

Typical Analysis in % by volume
87% N_2; 1.5% CO; 10.5% CO_2; 1% H_2;

Type 1b RICH MIXTURE: (Air-Gas Ratio 6:1) Q .281

Typical Analysis in % by volume
71.5% N_2; 10.5% CO; 5% CO_2; 12.5% H_2; .5% CH_4

EXOTHERMIC BASE

Above followed by passage thru incandescent charcoal bed.

Type 1c LEAN MIXTURE: (Air-Gas Ratio 9:1) Q .2855

Typical Analysis
78% N_2; 20% CO; 2% H_2

Type 1d RICH MIXTURE: (Air-Gas Ratio 6:1) Q .2855

Typical Analysis
67% N_2; 19% CO; 13.5% H_2; .5% CH_4

Type 2 PREPARED NITROGEN BASE

Prepared by the cumbustion of gas and air followed by the removal of the CO_2 and water vapor.

Type 2a LEAN MIXTURE: (Air-Gas Ratio 9:1) Q .2855

Typical Analysis
97% N_2; 2% CO; 1% H_2

Type 2b RICH MIXTURE: (Air-Gas Ratio 6:1) Q .2855

Typical Analysis
75% N_2; 11% CO; 13.5% H_2; .5% CH_4

Type 3 ENDOTHERMIC BASE

Gas-Air mixture reacted in externally heated catalyst filled chamber.

Type 3a PARTIALLY REACTED Q .2845

Typical Analysis
45% N_2; 20% CO; .5% CO_2; 34% H_2; .5% CH_4

Type 3b COMPLETELY REACTED Q .2845

Typical Analysis
40% N_2; 21% CO; 38% H_2; 1% CH_4

Type 4 CHARCOAL BASE Q .2855

Air passed thru externally heated charcoal filled chamber
Typical Analysis
64% N_2; 35% CO; 1% H_2

Type 5 AMMONIA BASE Q .2855

Ammonia dissociated in externally heated chamber.
Typical Analysis
25% N_2; 75% H_2

Type numbers are shown only to provide a cross reference between Table 2 and Table 3.

Following Tabulations from data available on some of the popular gas generators. Although the list is not complete, the data will be helpful in many instances.

TABLE 3

GENERATOR-MANUFACTURER	TYPE GAS	DESIGNATION	Q
American Gas Furnace Co.	5		.286
Associated Industrial Engineers	1a	Lean Exogen	.278
	1b	Rich Exogen	.281
	2	Monogan	.2855
	3	Endogen	.2845
	5	Amogen	.2855
Lindberg Engineering Co.	1a	Lean Hyex	.278
	1b	Rich Hyex	.281
	3	Hyen	.285
	4	Hyco	.285
	5	Hyam	.285
Mahr Mfg. Co.	2a	Prepared N_2	.285
	2b	No-ox	.285
Surface Combustion	1a	Lean DX	.278
	1b	Rich DX	.281
	2	NX	.285
	3	RX	.285
	4	Char-Mo	.285
	5	AX	.285
Whse. Electric Corp.	1a	Lean Exogas	.278
	1b	Rich Exogas	.281
	2	Monogas	.285
	3	Endogas	.285
	5	Amogas	.285
Electric Furnace Co.	1a	Cumbustion Type for non-ferrous Metals	.278
	1b	Standard Combustion Type	.281
	3	Endothermic Type	.285
General Electric Co.	1a	Lean Atmosphere Gas Converter	.278
	1b	Rich Atmosphere Gas Converter	.281
	1c	Drycolene	.285
	1c	Neutralene	.285
Hevi Duty Electric Co.	3	Cracked	.285

Use Of The Dew Point Calculator

To use the Dew Point Calculator the following values must be known

1. Q value of the gas.
2. The initial temperature of the gas as read on the thermometer on the Dew Pointer.
3. The pressure ratio required to just produce a fog.

If the Q value is .2855 proceed as follows:

1. Set the arrow "2" opposite the pressure ratio on scale "D".

2. Opposite the initial temperature on scale "F" read the Dewpoint temperature on scale "E".

NOTE: All temperatures are in degrees Fahrenheit.

EXAMPLE: Air is being tested so the Q value is .2855. The thermometer reads 75° F. A fog appears at a pressure ratio of .46, but does not appear at .47, therefore, the end point is .465.

1. Set the arrow "2" opposite .465 on scale "D".
2. Opposite 75 in scale "F", read the dewpoint temperature of -29.5° F. on the scale "E".

If the Q value is not .2855 proceed as follows:

1. Set the arrow "1" opposite the pressure ratio on Scale "A".
2. Opposite the Q value (Scale "C") read the "Equivalent Pressure Ratio" on Scale "B".
3. Set the arrow "2" opposite the "Equivalent Pressure Ratio" on Scale "D".
4. Opposite the initial temperature (Scale "F") read the dewpoint temperature on Scale "E".

EXAMPLE: Pure methane is being tested. The Q value is .24. The initial temperature is 80° F. A fog appears at .51 but does not appear at .52 so the end point is .515.

1. Set the arrow "1" opposite .515 (Scale "A").
2. Opposite .24 (Scale "C") read the equivalent pressure ratio of .57 on Scale "B".
3. Set the arrow "2" opposite .57 on Scale "D".
4. Opposite 80° F. on Scale "F" read the dewpoint of 0° F. on Scale "E".

Maintenance

To operate satisfactorily, the "Alnor" Dew Pointer must be free from leaks.

If the instrument does not hold pressure for one-half minute or more, corrective steps should be taken. Leaks can be located by applying soap water to valves and other parts subject to wear.

Wear on the operating valve packing can be taken up by tightening the top cap. The purging valve can be reseated by tightening the needle point into the seat. The needle point is made of stainless steel.

Bubbles in the oil column of the pressure ratio gauge can easily be removed by alternately pumping up the instrument and releasing the pressure. It helps to tilt the instrument forward or to the left.

If the oil is accidentally blown out thru the gauge valve additional oil can be added easily. Be sure the purging valve is open; operating valve up; and there is is no flow to the instrument. Remove the knurled knob on the filling well and unscrew the plug. Place the unity adjuster in its mid position. Depress the gauge valve and add oil by means of the eye dropper provided, until the column comes up to the 1 mark. Hold the dropper firmly in the filling well. Release the gauge valve before removing the dropper. Be sure that the plug is tightened in place before attempting to use the instrument.

The manometer oil supplied has a specific gravity of .834. Any other grade oil having approximately the same specific gravity can be used.

The pump piston should be lubricated occasionally with a good grade white petroleum jelly. Do not overlubricate.

The lamp is a standard No. 63 Mazda Lamp which can be obtained from any automotive supply shop.

An Alnor Type 7211 Battery, 7½ volt, is used.

The switch should be in the off position (on battery operated models) when the instrument is being transported to avoid unnecessary drain on the battery. For the same reason the switch should be in the A. C. position on A. C. and battery models when the instrument is being transported.

The observation window and the lens can be removed from the fog chamber for cleaning.

The fiberglass should be replaced occasionally, the frequency depending on the nature of the gas being tested and the frequency of use of the dewpointer. Since dust is generally hygroscopic even a small quantity of it may cause errors when testing a very dry gas.

Principle Of Operation

The principle of operation of the Dew Pointer is fundamental and simple. A thorough understanding of this principle will aid in the operation of the instrument.

The gas to be tested is pumped into the observation chamber at some pressure above atmospheric. The chamber is then rapidly exhausted to the atmosphere with a resultant expansion and cooling of the gas. If the cooling is sufficient to reduce the temperature of the gas to, or below, the dew point, water vapor will condense out in the form of a fine mist or fog. This fog is readily observable thru the observation window. Because of a light located below the fog chamber focused at the top of the chamber, the fog appears as a cone of sunbeams.

Successive trials will determine the minimum initial pressure which will produce a fog. The gas is then being cooled just to the dew point. The final temperature after expansion (the dew point) which is maintained for too brief an interval to measure, is then computed by means of the equation for an adiabatic expansion. The expansion is adiabatic (no heat added or subtracted during the process) because it is so rapid.

The following equation expresses a fundamental relationship between the pressure and temperature during an adiabatic expansion.

$$\text{Final Temp.} = \text{Initial Temp.} \left[\frac{\text{Final Pressure}}{\text{Initial Pressure}}\right]^{\frac{K-1}{K}}$$

where all values are in absolute units and

$$K = \frac{\text{specific heat at constant pressure}}{\text{specific heat at constant volume}}$$

For the "Alnor" Dew Pointer, the final temperature is the dew point temperature ($t_{D.P.}$). The ratio (P.R.) between the final pressure and initial pressure can be read directly on the pressure ratio gauge without necessity of knowing the individual quantities. By definition $Q = \frac{K-1}{K}$

The equation for an adiabatic expansion can, therefore, be converted into the following form for our purpose

$$t_{D.P.} = (t_i + 460)\,(P.R.)^{Q} - 460$$

when the temperatures are in ^{o} F.

Since the initial temperature (t_i) is read on the thermometer, P. R. is read on the pressure ratio gauge, and Q is a constant that depends on the gas being tested, it is apparent that the solution for the dew point temperature ($t_{D.P.}$) is perfectly straightforward though somewhat cumbersome. In actual use, a calculator is supplied that makes the above computation extremely simple.

The formation of a visible fog at the dew point temperature depends on the presence of dust in the gas to act as nuclei around which the droplets can form. In practically all cases dust is present. If, however, gas is completely dust free (such as gas produced by fractional distillation) it would be possible to cool the gas below the dewpoint temperature without condensing the moisture, if some substitute for the dust particles were not provided. Type 7000L and 7000U Dew Pointers are therefore equipped with a strip of radium foil built into the fog chamber. The Radium ionizes the gas in the chamber and the ions act as nuclei around which the droplets can form and build up to visible size. These Dew Pointers will, therefore, give the correct result regardless of the presence or absence of dust.

Operating Notes

When working with dry gases having low dew points, it should be remembered that extremely small quantities of water vapor are involved. It should further be remembered that the instrument can only give the result for the gas sample that is actually in the fog chamber. It is for this

reason that it is extremely important that the gas does not pick up or lose moisture in the process of being transferred from its source to the fog chamber.

Copper tubing is the most satisfactory material for connecting the instrument to the source of gas because it is not hygroscopic. The use of rubber tubing will almost certainly contaminate the gas sample. A dense neoprene tubing is satisfactory except for very dry gases.

It is for the same reason that the filter material should be replaced occasionally. If an appreciable quantity of dust is allowed to accumulate in the filter, the moisture content of the gas may be altered as it passes through the filter.

The built in hand pump is double acting. The gas flowing on the top side of the piston is discharged through the outlet without flowing through the fog chamber.

The only function of this gas is to keep the pump barrel dry and avoid contamination of the test gas.

Thorough initial purging of the instrument is important. Reference to the vapor density curves (figs. 7 & 8) show that the vapor density at 50° F. is .59 lbs. per 1000 cu. ft. and the vapor density at -70° F. is only .0019 lbs. per 1000 cu. ft. If the instrument were originally filled with air having a dew point of 50° F. and only .1% of the original volume were left in the chamber due to inadequate purging the instrument would give an indication that was 3° high when testing a sample of gas having a dew point of -70°F.

It is, of course, important to have all connections tight on the inlet side of the instrument. In some cases momentary negative pressures can be caused in the inlet line by the operation of the hand pump. If there were a leak in the inlet line atmospheric air could flow in and add moisture to the sample during these short periods of negative pressure. Furthermore, the vapor pressure of the air is generally higher than the vapor pressure of the gas being tested. It is, therefore, possible for water vapor to flow in through a leaky connection even when the gas pressure is above atmospheric.

PARTIAL PARTS LIST FOR DEW POINTER TYPE 7000 (SERIAL #500 AND OVER)

PART #	DESCRIPTION	PART #	DESCRIPTION
7009	Inlet fitting	7176	S.P.S.T. Toggle Switch
7010	Oil Refill Assembly	7177	D.P.D.T. Toggle Switch
7020	Purging Valve Assembly	7190	Mercury Switch Assembly
7057	Fog Chamber Gasket Top (2)	7192	Hose Nipple Connector
7058	Fog Chamber Gasket Bottom (2)	7193	Tubing Nipple Connector
7059	Fog Chamber Lens	7205	Lamp Socket
7061	Fog Chamber Window Glass	7206	Lamp Mazda 6-8 Volt
7070	Unity Adjuster Assembly	7210	Transformer
7104	Filter Cap	7211	Battery G5 7.5 Volt
7105	Filter Gasket	7212	Battery Male Plug
7106	Filter Screen	7220	Connector Cable Assembly
7109	Filter Fiber Glass	7229	Wrench
7127	Pump Piston "O" Ring	7231	Bottle Manometer Oil with Dropper
7154	Thermometer 30-110° F.	7226	Outlet Assembly
		7140	Pump Piston Assembly

APPENDIX

Q Value Of Mixtures

A mixture of gases can be treated as a single gas if the proper constants are established. The value of Q can be computed by one of the following methods.

METHOD 1 - MASS BASIS

Since the effect that the specific heat of an individual gas has on the specific heat of the mixture is proportional to the mass of the gas present the following equation can be written.

(1) $C_{pm}=\frac{M_x}{M_m} C_{px}+\frac{M_y}{M_m} C_{py}+\text{----}+\frac{M_z}{M_m} C_{pz}$

(2) $C_{vm}=\frac{M_x}{M_m} C_{vx}+\frac{M_y}{M_m} C_{vy}+\text{----}+\frac{M_z}{M_m} C_{vz}$

Where

C_{pm} = Specific heat at constant pressure of the mixtures

C_{vm} = specific heat at constant volume of the mixture

C_{vx}, C_{vy}, & C_{vz} = specific heat at constant volume of each gas.

C_{px}, C_{py}, & C_{pz} = specific heat at constant pressure of each gas.

M_m = total weight of the mixture

M_x, M_y & M_z = weight of each gas

Specific heats are expressed in heat units per weight unit per temperature unit such as B.T.U. per pound per ^{o} F.

Then

(3) $K_m=\frac{C_{pm}}{C_{vm}}$

and

(4) $Q_m=\frac{K_m-1}{K_m}$ or from figure 3

where

K_m = K value for the mixture

Q_m = Q value for the mixture

It is only necessary to insert the proper values in equations (1) and (2) and then solve.

EXAMPLE FOR METHOD 1

A mixture of gas is known to be composed of the following:

20% by weight CH_4
40% by weight CO_2
40% by weight N_2

Find the value of Q

Substituting in equations 1 and 2

C_{pm}=.2 (.593)+.4 (.200)+.4 (.247)=.2974

C_{vm}= .2 (.450)+.4 (.155)+.4 (.176)=.2244

Then

$K_m=\frac{.2974}{.2224}=1.337$

and

$Q_m=\frac{.337}{1.337}=.252$

METHOD 2 - VOLUMETRIC BASIS

When a mixture of gases is analyzed with an Orsat apparatus the percentages of each component are determined on a volumetric basis. It is, therefore, essential that these volumetric percentages be converted to weight percentages before Method 1 can be used.

(5) $\frac{M_x}{M_m}=\frac{Xd_x}{d_m}$ $\frac{M_y}{M_m}=\frac{Yd_y}{d_m}$; etc.

where

X = percent by volume of gas X

d_x = density of gas X

d_m = density of the mixture

Notice that any condition of temperature and pressure and any units of density can be used provided the same conditions and units are used thruout.

Equations 1, 2, 3, & 5 can be combined and multiplied by $\frac{d_m}{d_m}$ to following simple form.

(6) $K_m=\frac{Xd_xC_{px}+Yd_yC_{py}+\text{---}+Zd_zC_{pz}}{Xd_xC_{vx}+Yd_yC_{vy}+\text{---}+Zd_zC_{vz}}$

Where X, Y and Z are volumetric percentages of each gas and d_x, d_y, and d_z are the density of each gas.

Since the values of d_xC_{px} are presented in Table 4 the solution of Equation 6 is extremely simple. Q can be obtained from Figure 3. Because of similarity of values CO, O_2, H_2, and N_2, can be considered one gas.

K TO Q CONVERSION CURVE

FIG. 3

ILLINOIS TESTING LABORATORIES, INC.
420 NORTH LASALLE STREET — CHICAGO 10, ILLINOIS

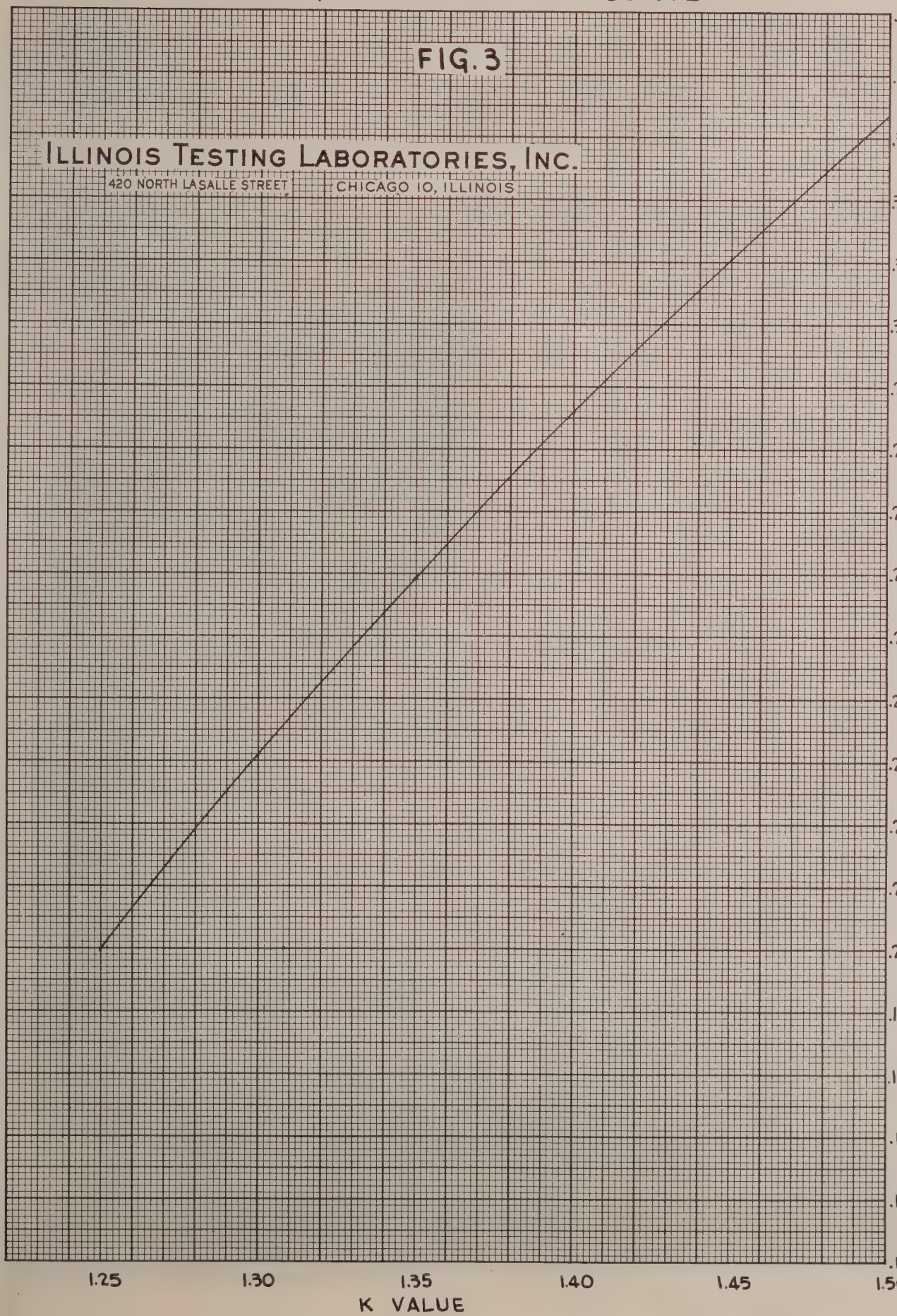


TABLE 4

Gas	Density lbs/ c.f. @62°F.	C_p B.T.U. per lb.	C_v B.T.U. per lb.	(d)C_p B.T.U. per c.f.	(d)C_v B.T.U. per c.f.	K	Q
CO	.0735	.245	.175	.0180	.0128	1.40	.2855
N_2	.0737	.247	.176	.0182	.0130	1.40	.2855
O_2	.0840	.217	.155	.0182	.0130	1.40	.2855
Air	.0757	.241	.171	.0182	.0130	1.40	.2855
H_2	.00529	3.42	2.44	.0181	.0129	1.40	.2855
CO_2	.1156	.200	.155	.0231	.0179	1.29	.225
CH_4	.0421	.593	.450	.0250	.0190	1.315	.240

Notice that all diatomic gases listed can be treated as a single gas for all practical purposes.

EXAMPLE FOR METHOD 2

A mixture of gases is known to consist of the following:

72% by volume N_2

12.5% by volume of H_2

10% by volume of CO

5% by volume of CO_2

.5% by volume CH_4

Find the value of Q

Substituting in equation 6

Gas	Numerator	Denominator
N_2	.72 (.0182) = .01310	.72 (.0130) = .00936
CO	.10 (.0180) = .00180	.10 (.0128) = .00128
CO_2	.05 (.0231) = .00116	.05 (.0179) = .00090
H_2	.125 (.0181) = .00226	.125 (.0129) = .00161
CH_4	.005 (.0250) = .00013	.005 (.0190) = .00010
	.01845	.01325

$$K_m = \frac{.01843}{.01325} = 1.392 \qquad Q_m = .281$$

METHOD 3 - CURVES

A great many commonly used mixtures primarily consist of only one gas other than diatomic gases. For these mixtures values of Q can be picked off of the curves in Figure 4.

The curves in Figure 4 are plotted for mixtures which consist of percentages of the gas named where the balance of the mixture is N_2, O_2, H_2 or CO. If small percentages of other gases are present, they can be ignored.

EXAMPLE - METHOD 3

Given the mixture specified for the example of Method 2 find the value of Q by use of Figure 4.

Since the values of d (C_p) and d (C_v) are so nearly equal for all the diatomic gases assume that they are actually one gas having the characteristics of N_2. Since the volume of CH_4 is small add it to the CO_2 for this purpose, then the analysis of the gas becomes

5.5% by volume CO_2

94.5% by volume N_2

From Figure 4 Q = .281

Q VALUE OF GAS MIXTURES

FIG. 4

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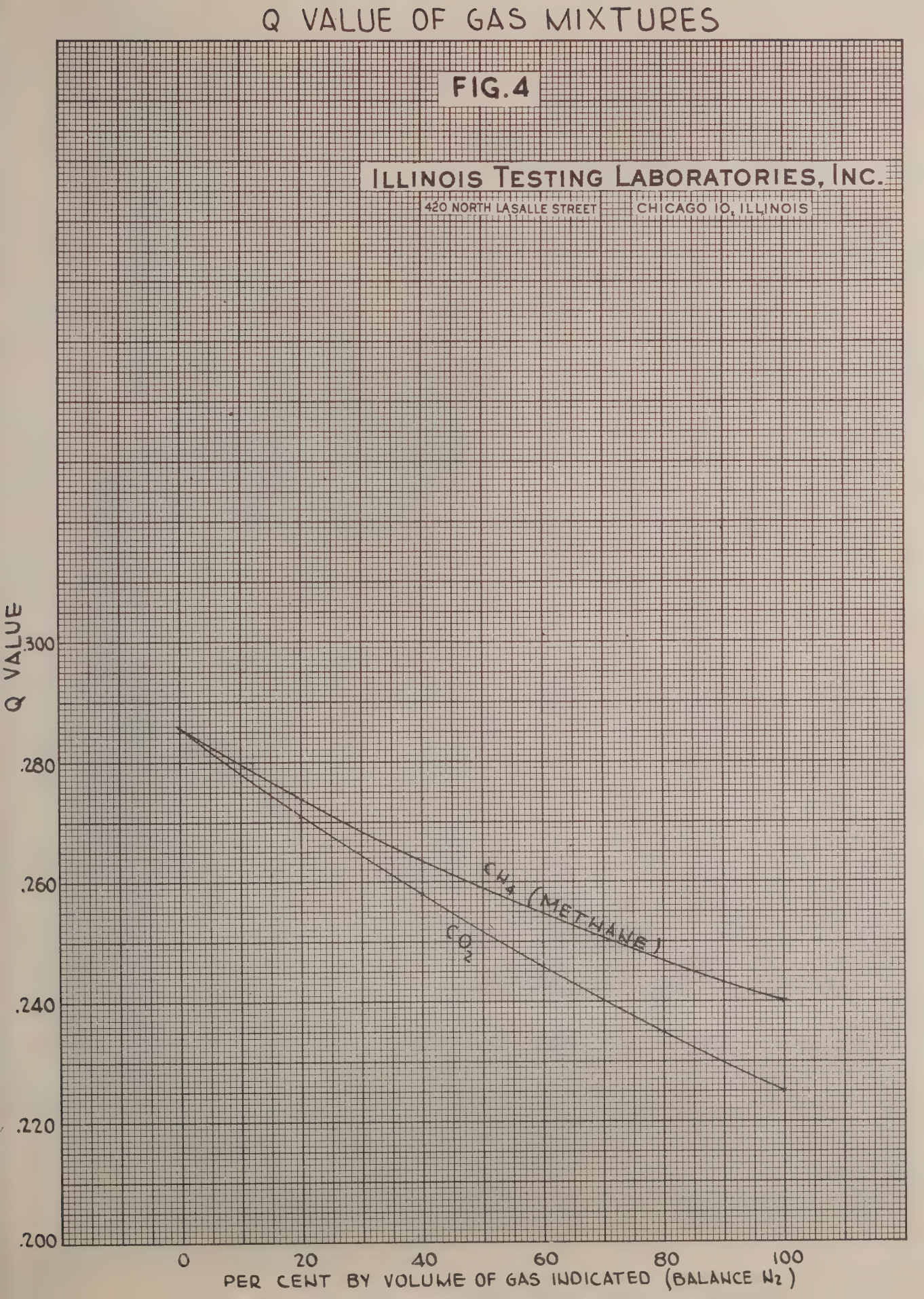


ACCURACY OF GAS ANALYSIS

An error of .005 in the Q value will produce an error of approximately 2° F. when the pressure ratio is .4; the error will be less for higher pressure ratios. It is, therefore, apparent an error of about 10% in the volumetric analysis of CH_4 or about 7% in the volumetric analysis of CO_2 is generally permissible. It is, therefore, evident that the "Alnor" Dew Pointer is not dependent upon an accurate gas analysis as far as common mixtures are concerned. It is obviously not necessary to make an Orsat analysis prior to each dew point test.

Figure 5 graphically shows the effect of Q value in the dew point determination assuming an initial temperature of 80° F. For comparatively high dew points (above 0° F.) this value is far from critical. For lower dew points the value of Q should be known with greater accuracy.

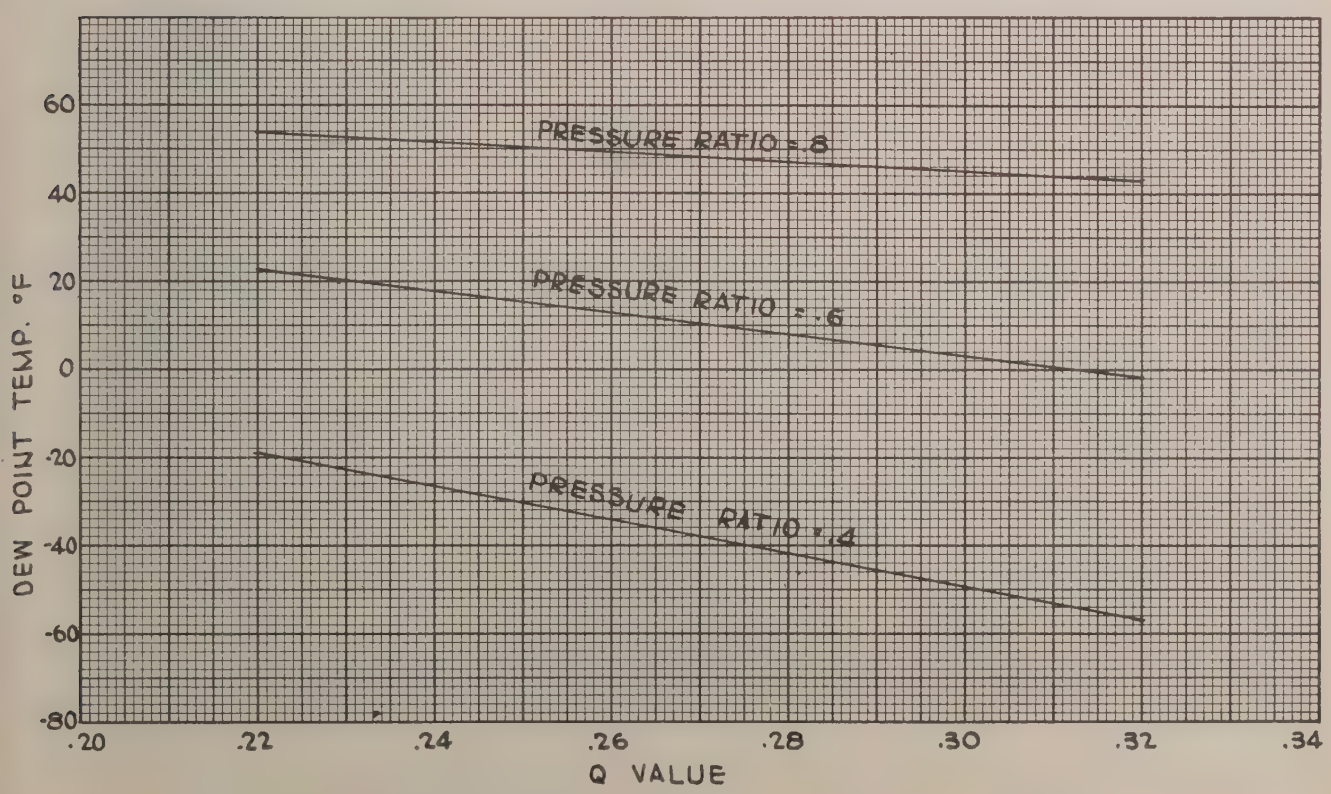
VAPOR DENSITY AND VAPOR PRESSURE

For each dew point there is a corresponding water vapor pressure and water vapor density. The "Alnor" Dew Pointer might just as well have been named a "Vapor Pressure Tester" or "Vapor Density Gauge". The following curves have been provided to permit easy transfer from one set of values to another as the need arises.

For dew points below freezing there are theoretically two possible values for vapor pressure, that is, vapor pressure over ice or vapor pressure over water. There is considerable experimental evidence indicating that the vapor pressure of air corresponds with the vapor pressure of sub-cooled water, whether the air is actually in contact with sub-cooled water or with ice. Accordingly the vapor pressures plotted on the following curves correspond with the vapor pressures over sub-cooled water. Vapor densities are plotted on the same basis.

FIG. 5

EFFECT OF Q VALUE ON DEW POINT INDICATION AT VARIOUS PRESSURE RATIOS. INITIAL TEMPERATURE = 80° F



VAPOR PRESSURE AND VAPOR DENSITY CURVES

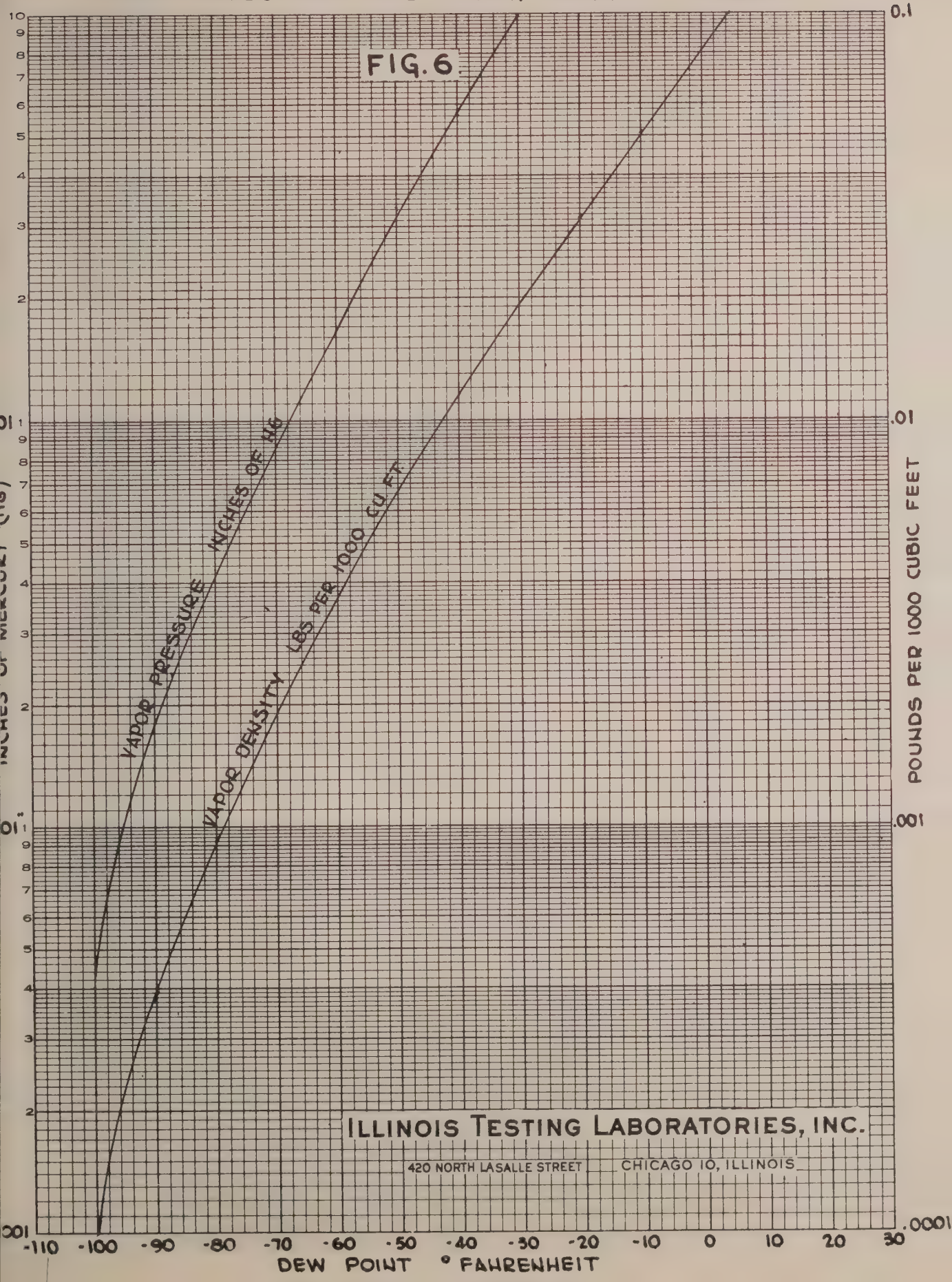


FIG. 6
VAPOR PRESSURE INCHES OF Hg
VAPOR DENSITY LBS PER 1000 CU FT
INCHES OF MERCURY (Hg)
POUNDS PER 1000 CUBIC FEET
0.1
.01
.001
.0001
-110 -100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30
DEW POINT ° FAHRENHEIT
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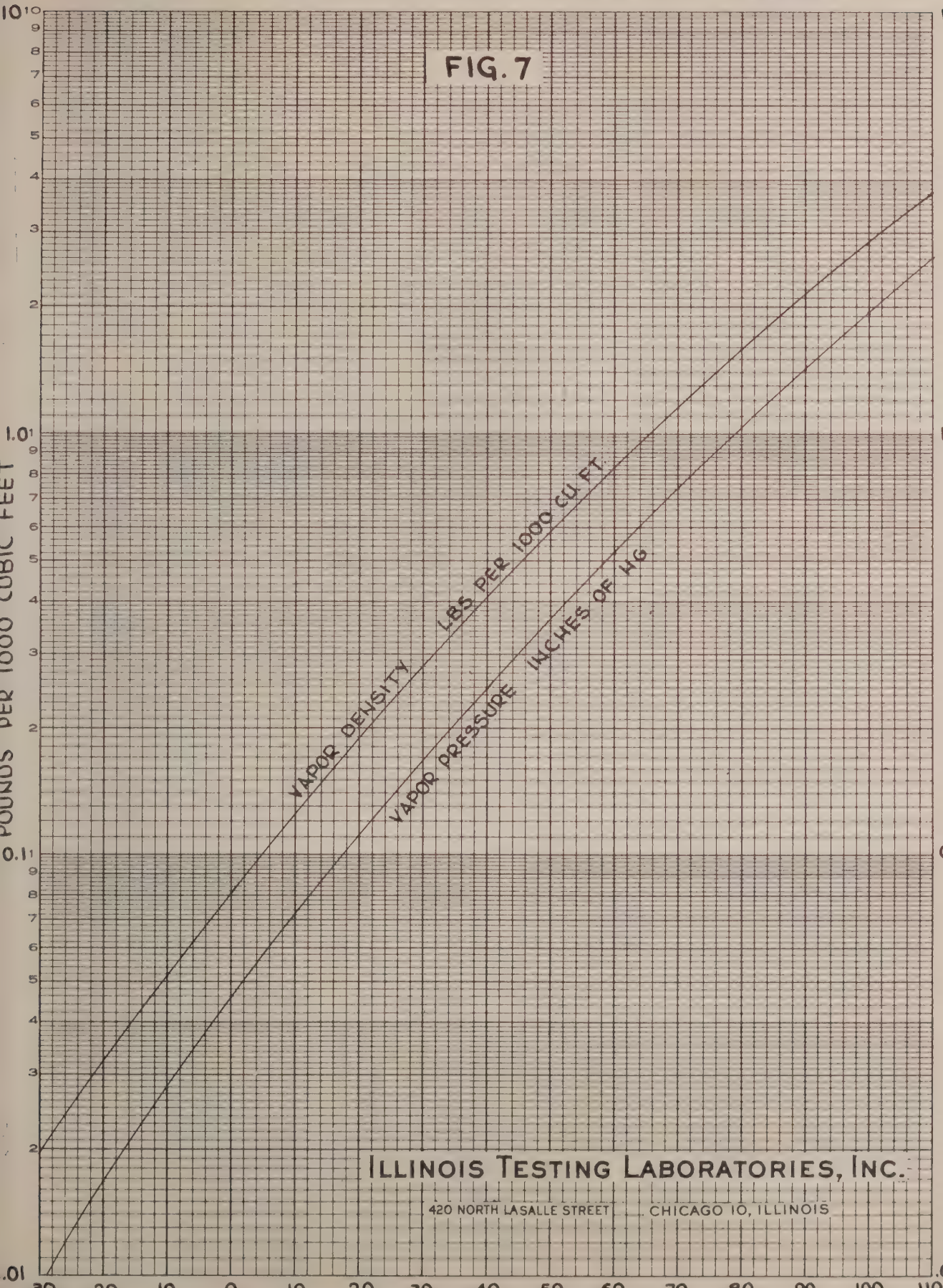
VAPOR PRESSURE AND VAPOR DENSITY CURVES

FIG. 7


POUNDS PER 1000 CUBIC FEET
INCHES OF MERCURY (Hg)
VAPOR DENSITY LBS PER 1000 CU FT
VAPOR PRESSURE INCHES OF Hg
10
1.0
0.1
.01
-30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110
DEW POINT °FAHRENHEIT

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THE DEW POINTER AS A "GO, NO-GO GAUGE'

For shop use it is frequently desirable to use the Dew Pointer as a Go, No-Go Gauge. In this case the operation of the instrument becomes so simple that comparatively unskilled workmen can use it.

As an example assume a situation where a gas having a Q value of .2855 is carried in a pipe line at 1 pound gauge pressure. The process is to be operated so that the dew point is kept below 0° F. By performing the operations in reverse order the Dew Point Calculator can be used to develop a chart as follows:

1. Set the initial temperature opposite the critical Dew Point Temperature.
2. Opposite the arrow under (2) read the pressure ratio.

FOR 0° F. DEW POINT

Q .2855

Thermometer	Pressure Ratio Gauge
70	.61
72	.60
74	.59
76	.583
78	.577
80	.57

The instrument can be left connected to the gas line continously with the purge valve cracked so that a small amount of gas is bleeding thru continously. Thus no additional purging would be required. All the operator would have to do is read the thermometer - close the purging valve - pump the instrument up to the indicated pressure ratio - pause for fifteen seconds - and press the operating valve. If a fog appears the dew point is above 0° F.

DEW POINTS AT ELEVATED PRESSURES

If a sample of gas is compressed it is apparent the vapor pressure is increased. The compressed gas, therefore, has a higher dew point that corresponds to the new vapor pressure.

The "Alnor" Dew Pointer gives the dew point at atmospheric pressure. When the corresponding dew point at higher pressures is required refer to Figure 8.

Example: A gas is carried in a pipe line at 585 pound gauge pressure. The "Alnor" Dew Pointer indicates the dew point is -65° F. What is the actual dew point in the pipe line.

Answer is 1° F.

PSYCHROMETRIC CHART

Figure 9 shows the relationship between dew point temperatures, dry bulb temperatures, and relative humidity in the low humidity regions which are difficult to to read on the usual psychrometric chart. The "Alnor" Dew Pointer is particularly useful for making humidity measurements in this comparatively dry region.

Relative humidity is by definition the ratio of the actual vapor pressure of water vapor (the saturated vapor pressure at the dew point) in an air-vapor mixture to its saturated vapor pressure at the dry bulb temperature.

Relative humidity may also be defined as ratio of the weight of water vapor in one cubic foot of the mixture as indicated by its dew point, to the weight of water vapor in one cubic foot of a saturated mixture at the dry bulb temperature.

Example: Dry Bulb Temperature 80° F.
Dew Point Temperature 0° F.

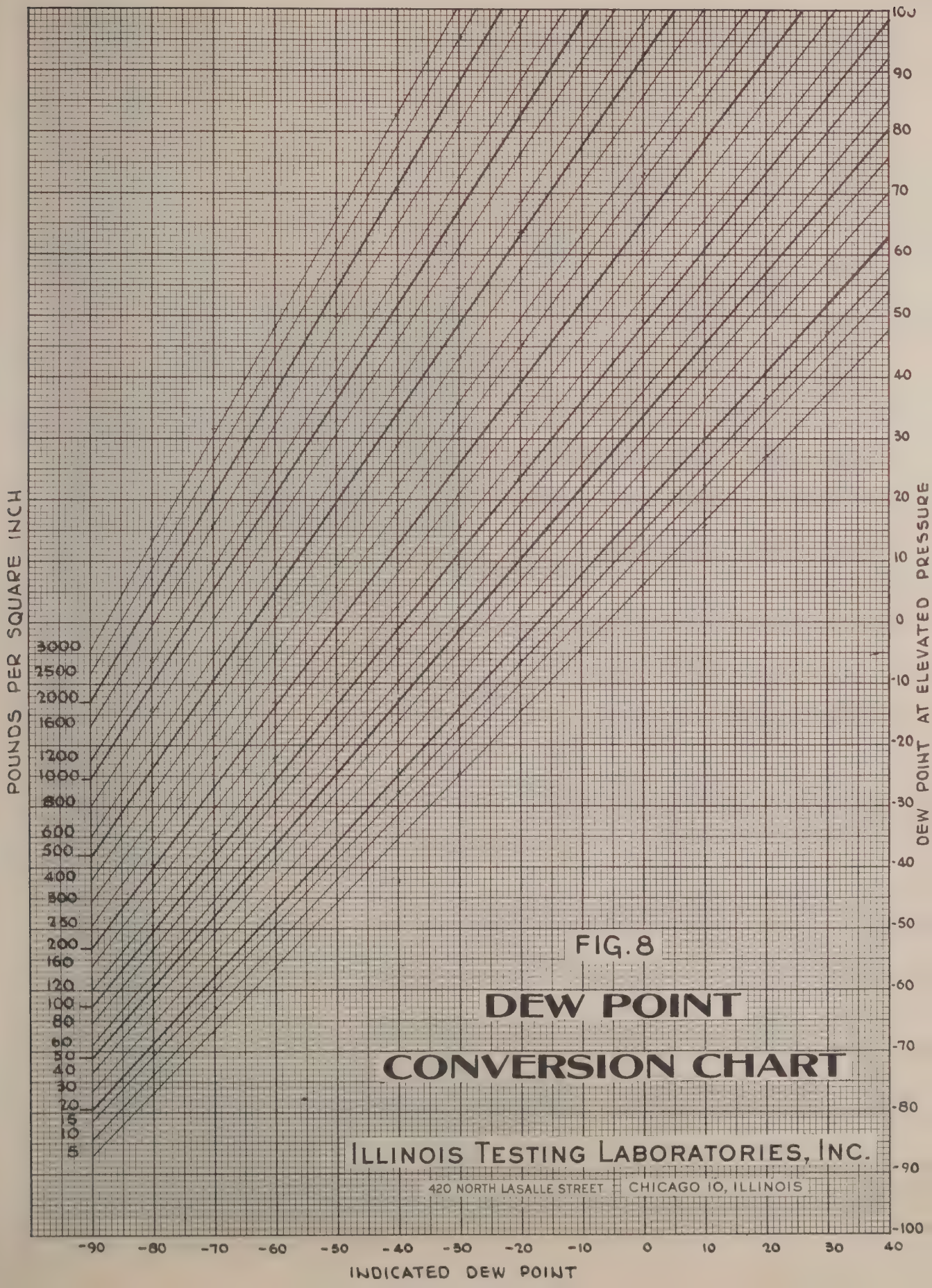
What is the Relative Humidity?
Answer from Figure 9 4.4%

Figure 10 is a standard Psychrometric Chart. In addition to dew point temperatures, dry bulb temperatures and relative humidity, it shows wet bulb temperatures, grains of water vapor per cubic foot, grains of water vapor per pound of dry air and the volume of the mixture in cubic feet of mixture per pound of dry air.

Example: Dry Bulb Temperature 90° F.
Dew Point Temperature 50° F.

What other values can be read from the Psychrometric Chart?

Answer: Wet Bulb Temperature 65° F.
Relative Humidity 25%.
Volume of the Mixture 14.0 per cu. ft. of dry air.
Density of the vapor 4.11 grains per cu. ft.
Weight of the vapor 53.4 grains per lb. of dry air.


POUNDS PER SQUARE INCH
3000
2500
2000
1600
1200
1000
800
600
500
400
300
250
200
160
120
100
80
60
50
40
30
20
15
10
5
DEW POINT AT ELEVATED PRESSURE
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40
INDICATED DEW POINT
FIG. 8
DEW POINT
CONVERSION CHART
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PSYCHROMETRIC CHART

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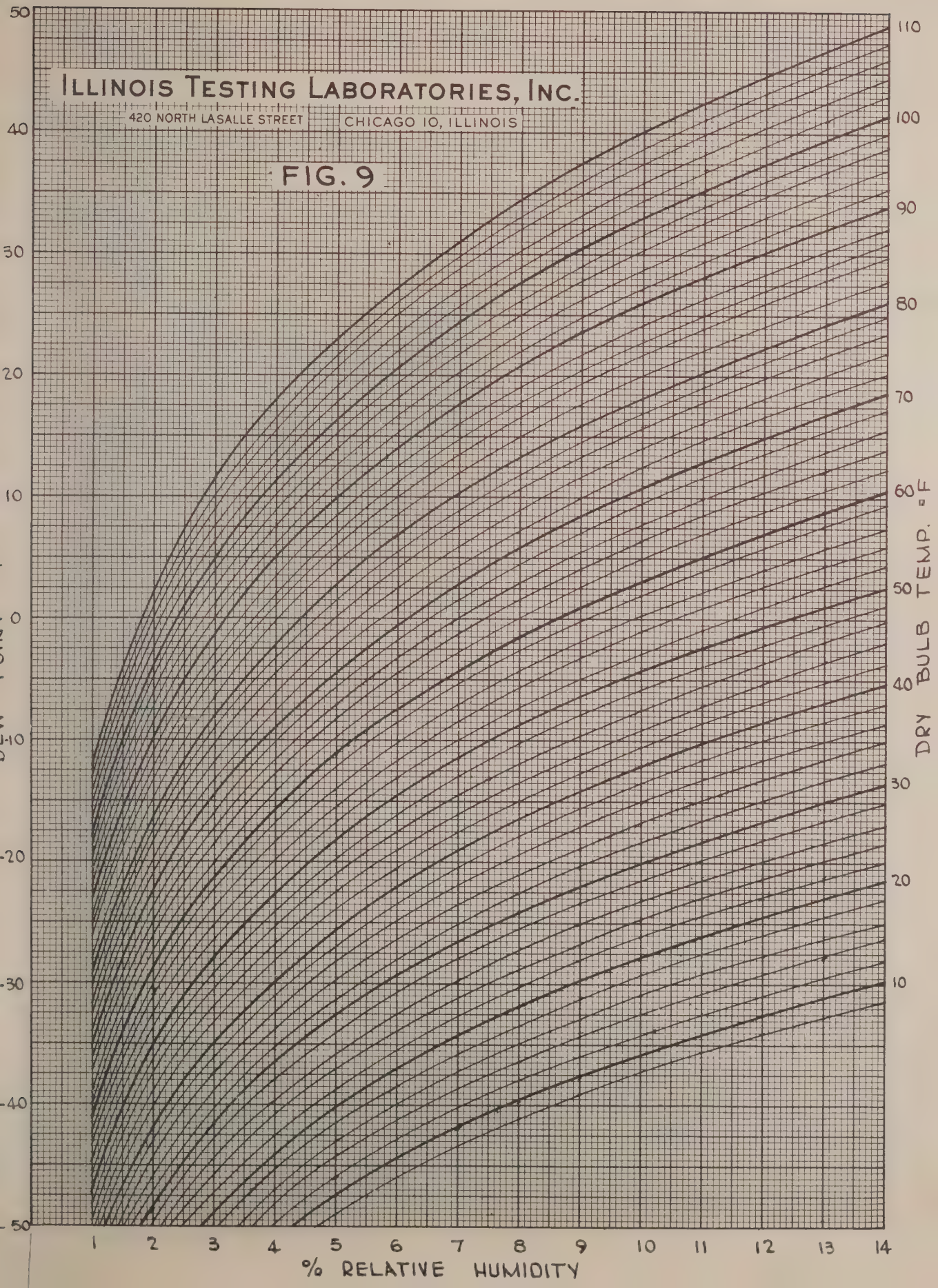
FIG. 9



PSYCHROMETRIC CHART

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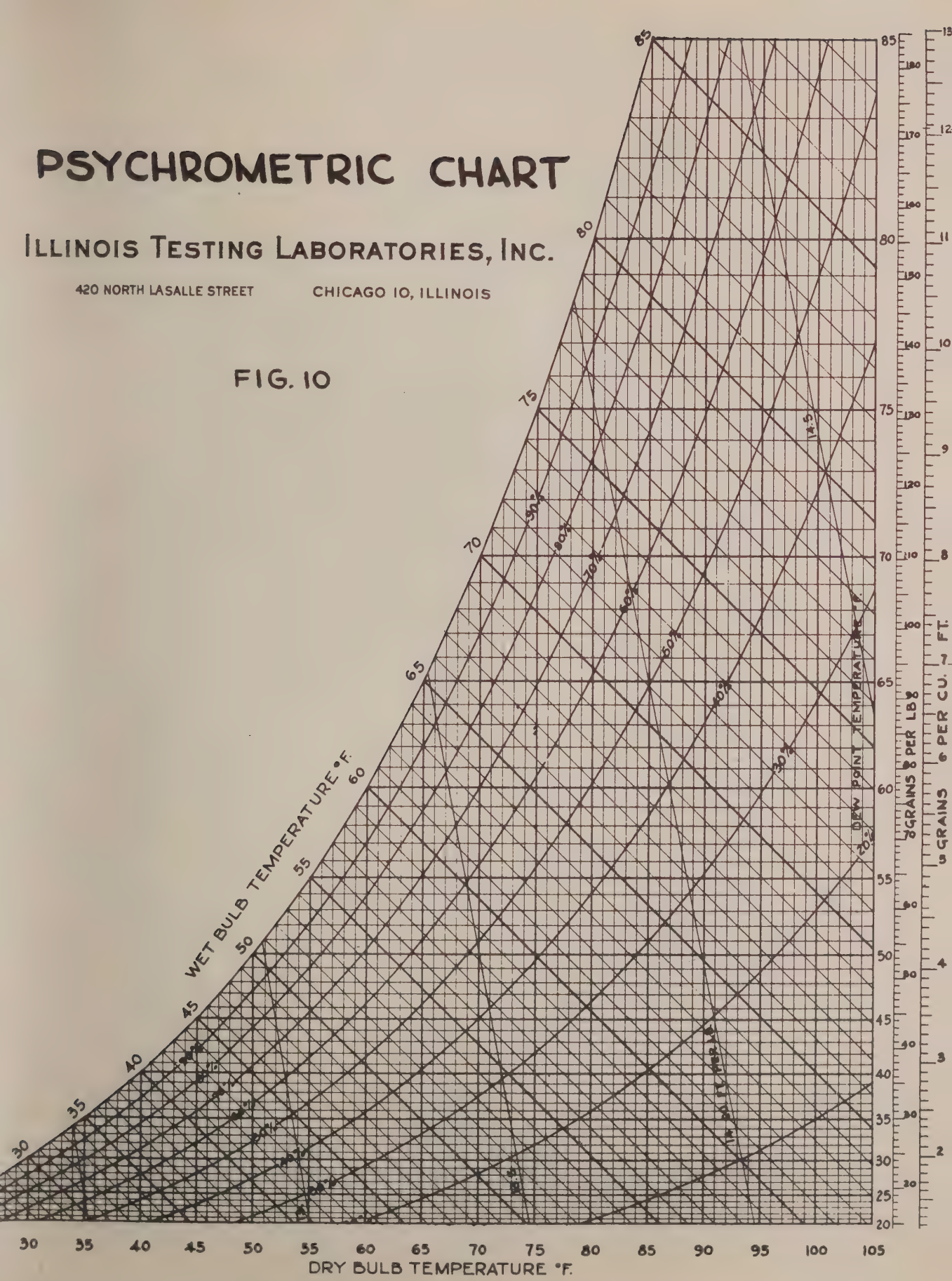
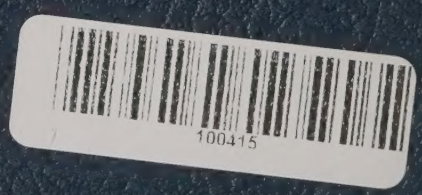
FIG. 10


WET BULB TEMPERATURE °F.
DRY BULB TEMPERATURE °F.
DEW POINT TEMPERATURE °F.
GRAINS OF MOISTURE PER LB. DRY AIR
GRAINS PER CU. FT.
30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105
85 80 75 70 65 60 55 50 45 40 35 30 25 20
90% 80% 70% 60% 50% 40% 30% 20%
14.5

TEMPERATURE CONVERSION TABLE

°C		°F	°C		°F	°C		°F	°C		°F
-73.3	-100	-148	-45.6	-50	-58.0	-17.8	0	32.0	10.0	50	122.0
-72.8	-99	-146.2	-45.0	-49	-56.2	-17.2	1	33.8	10.6	51	123.8
-72.2	-98	-144.4	-44.4	-48	-54.4	-16.7	2	35.6	11.1	52	125.6
-71.7	-97	-142.6	-43.9	-47	-52.6	-16.1	3	37.4	11.7	53	127.4
-71.1	-96	-140.8	-43.3	-46	-50.8	-15.6	4	39.2	12.2	54	129.2
-70.6	-95	-139.0	-42.8	-45	-49.0	-15.0	5	41.0	12.8	55	131.0
-70.0	-94	-137.2	-42.2	-44	-47.2	-14.4	6	42.8	13.3	56	132.8
-69.4	-93	-135.4	-41.7	-43	-45.4	-13.9	7	44.6	13.9	57	134.6
-68.9	-92	-133.6	-41.1	-42	-43.6	-13.3	8	46.4	14.4	58	136.4
-68.3	-91	-131.8	-40.6	-41	-41.8	-12.8	9	48.2	15.0	59	138.2
-67.8	-90	-130.0	-40	-40	-40	-12.2	10	50.0	15.6	60	140.0
-67.2	-89	-128.2	-39.4	-39	-38.2	-11.7	11	51.8	16.1	61	141.8
-66.7	-88	-126.4	-38.9	-38	-36.4	-11.1	12	53.6	16.7	62	143.6
-66.1	-87	-124.6	-38.3	-37	-34.6	-10.6	13	55.4	17.2	63	145.4
-65.6	-86	-122.8	-37.8	-36	-32.8	-10.0	14	57.2	17.8	64	147.2
-65.0	-85	-121.0	-37.2	-35	-31.0	-9.4	15	59.0	18.3	65	149.0
-64.4	-84	-119.2	-36.7	-34	-29.2	-8.9	16	60.8	18.9	66	150.8
-63.9	-83	-117.4	-36.1	-33	-27.4	-8.3	17	62.6	19.4	67	152.6
-63.3	-82	-115.6	-35.6	-32	-25.6	-7.8	18	64.4	20.0	68	154.4
-62.8	-81	-113.8	-35.0	-31	-23.8	-7.2	19	66.2	20.6	69	156.2
-62.2	-80	-112.0	-34.4	-30	-22.0	-6.7	20	68.0	21.1	70	158.0
-61.7	-79	-110.2	-33.9	-29	-20.2	-6.1	21	69.8	21.7	71	159.8
-61.1	-78	-108.4	-33.3	-28	-18.4	-5.6	22	71.6	22.2	72	161.6
-60.6	-77	-106.6	-32.8	-27	-16.6	-5.0	23	73.4	22.8	73	163.4
-60.0	-76	-104.8	-32.2	-26	-14.8	-4.4	24	75.2	23.3	74	165.2
-59.4	-75	-103.0	-31.7	-25	-13.0	-3.9	25	77.0	23.9	75	167.0
-58.9	-74	-101.2	-31.1	-24	-11.2	-3.3	26	78.8	24.4	76	168.8
-58.3	-73	-99.4	-30.6	-23	-9.4	-2.8	27	80.6	25.0	77	170.6
-57.8	-72	-97.6	-30.0	-22	-7.6	-2.2	28	82.4	25.6	78	172.4
-57.2	-71	-95.8	-29.4	-21	-5.8	-1.7	29	84.2	26.1	79	174.2
-56.7	-70	-94.0	-28.9	-20	-4.0	-1.1	30	86.0	26.7	80	176.0
-56.1	-69	-92.2	-28.3	-19	-2.2	-0.6	31	87.8	27.2	81	177.8
-55.6	-68	-90.4	-27.8	-18	-.4	0	32	89.6	27.8	82	179.6
-55.0	-67	-88.6	-27.2	-17	1.4	0.6	33	91.4	28.3	83	181.4
-54.4	-66	-86.8	-26.7	-16	3.2	1.1	34	93.2	28.9	84	183.2
-53.9	-65	-85.0	-26.1	-15	5.0	1.7	35	95.0	29.4	85	185.0
-53.3	-64	-83.2	-25.6	-14	6.8	2.2	36	96.8	30.0	86	186.8
-52.8	-63	-81.4	-25.0	-13	8.6	2.8	37	98.6	30.6	87	188.6
-52.2	-62	-79.6	-24.4	-12	10.4	3.3	38	100.4	31.1	88	190.4
-51.7	-61	-77.8	-23.9	-11	12.2	3.9	39	102.2	31.7	89	192.2
-51.1	-60	-76.0	-23.3	-10	14.0	4.4	40	104.0	32.2	90	194.0
-50.6	-59	-74.2	-22.8	-9	15.8	5.0	41	105.8	32.8	91	195.8
-50.0	-58	-72.4	-22.2	-8	17.6	5.6	42	107.6	33.3	92	197.6
-49.4	-57	-70.6	-21.7	-7	17.6	6.1	43	109.4	33.9	93	199.4
-48.9	-56	-68.8	-21.1	-6	21.2	6.7	44	111.2	34.4	94	201.2
-48.3	-55	-67.0	-20.6	-5	23.0	7.2	45	113.0	35.0	95	203.0
-47.8	-54	-66.2	-20.0	-4	24.8	7.8	46	114.8	35.6	96	204.8
-47.2	-53	-63.4	-19.4	-3	26.6	8.3	47	116.6	36.1	97	206.6
-46.7	-52	-61.6	-18.9	-2	28.4	8.9	48	118.4	36.7	98	208.4
-46.1	-51	-59.8	-18.3	-1	30.2	9.4	49	120.2	37.8	100	212.0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